The End is Near!

A concrete solution to moisture-related flooring problems

BY RANDY TURPIN AND PETER CRAIG

Every year, moisture-related flooring problems (and the disputes that follow) add hundreds of millions of dollars to project costs. Scores of topical approaches have been introduced to try to mitigate the effects of high moisture levels in concrete slabs. These treatments, however, can add significant costs to a project, be disruptive to apply, and, to date, have not proven to be 100% effective.

THE PROBLEM

The effects of a high moisture condition in concrete can be damaging to modern-day flooring installations. Adhesive breakdown, debonding, and blistering are all conditions related to moisture and moisture-induced high pH levels that develop when moisture in concrete is high enough to place soluble alkali salts in concrete into solution.

Adhesive, flooring, and coating manufacturers have responded by specifying maximum concrete moisture levels needed prior to the installation of their products. Unfortunately, it's rare for conventional concrete to dry naturally to these levels within desired project schedules.

Also, the state of concrete dryness is often not known until shortly before flooring materials are to be installed. If tests show that the concrete is too wet for flooring installation, meeting the project schedule may force the installation of an expensive topical solution—an installation that's especially challenging and disruptive because the interior walls may already be in place. A better approach is needed.

THE CONCRETE SOLUTION

Over the years, a number of approaches have been tried to accelerate the drying time of concrete. These have included the development of quick-drying mixtures with low water-cement ratios (w/c).[1,2] While these first-generation mixtures can be effective in hastening concrete's drying time, they have proven to be too difficult to place and finish on a regular basis.

Today, things are about to change. After more than 6 years of development, laboratory testing, and field verification, a new concrete solution has been developed that combines the benefit of rapid drying with placement and finishing characteristics similar to those for conventional concrete.

Called Aridus™ (Latin for "dry"), this new portland cement-based concrete solution combines years of practical experience, modern proportioning technology, and a unique chemistry. The new concrete not only dries quickly, but it's also not seriously affected by re-wetting. Yet, this unique concrete mixture can be placed using conventional equipment, including concrete pumps, and it can be finished using standard equipment, including laser screeds, conventional vibratory screeds, pan floats, and power trowels.

The Advantages

The significant advantage to this cost-effective concrete solution is its ability to stop slab moisture problems from the very beginning. No longer will project schedules need to be disrupted by extended drying times or the time required to apply a topical moisture and pH suppression system. Eliminating slab moisture issues from the beginning will spare owners and the project team the aggravation and cost of dealing with post-installation corrections to failed flooring. Disputes over responsibility and cost will be avoided, so everyone will be able to complete their tasks and responsibilities without interruption.

Results of field and laboratory moisture testing of this new concrete solution indicate that, on most projects, the concrete will be ready to accept flooring in less than 30 days following watertight enclosure of the building.

Testing program

In controlled laboratory tests, Aridus concrete dried to 75% internal relative humidity (RH) in as little as 15 days.

An extremely low *w/c* concrete control mixture (0.41) took almost 2 months longer to reach the same level (Fig. 1). In other controlled studies, concrete mixtures with a *w/c* of 0.50 have taken more than a year, under ideal drying conditions, to reach less than 80%.

The minimal effect that re-wetting of the slab has on the moisture vapor emission rate (MVER) is shown in Fig. 2. In contrast to conventional concrete, the new mixture has an internal drying mechanism.

Because this process does not rely on surface evaporation to reduce internal moisture, the Aridus mixture exhibits practically no curl (warping). This mechanism was tested using curling specimens (Fig. 3). The contrast in the amount of curl is dramatic, as the new mixture stabilizes shortly after construction. The degree of curl for the

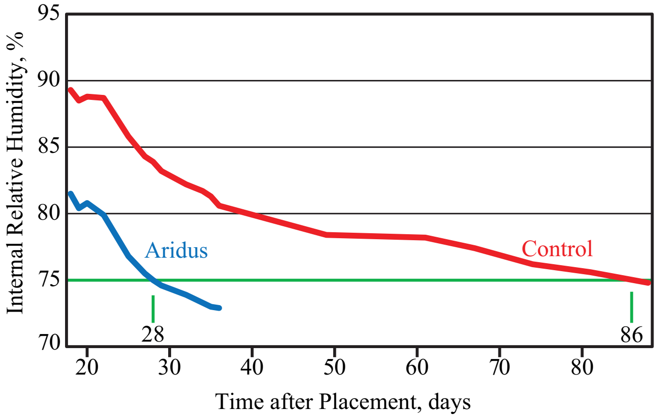


Fig. 1: Internal RH versus time for an Aridus mixture and a control mixture with *w/c* = 0.41; both were tested per ASTM F2170. Although both mixtures show rapid initial moisture loss, the control mixture required almost 2 months more time to reach a typically specified level of 75% RH

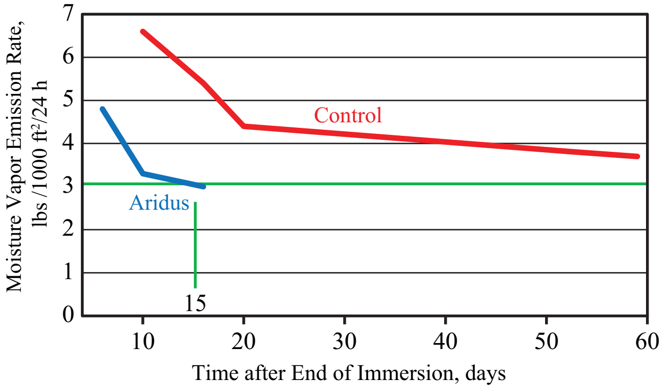


Fig. 2: MVER versus time for an Aridus mixture and a control mixture with *w/c* = 0.41; both were tested per ASTM F1869. Although both mixtures show rapid initial moisture loss, the control mixture never reached the typically specified acceptable MVER of 3 lb/1000 ft²/24 h [170 μg/(s·m²)]

Fig. 3: Curl test specimens were tested with one end anchored to the test floor and the other end free to rise as warping stresses developed. Specimens were cover cured for 7 days, using polyethylene. The forms were then removed, and the bottoms and sides of the specimens were sealed with polyolefin tape. The test specimens were anchored to the floor at one end and the top surface of each specimen was diamond ground to hasten moisture loss. Dial gauges were installed and used to monitor uplift of the free end, to the nearest 0.001 in. (0.025 mm)

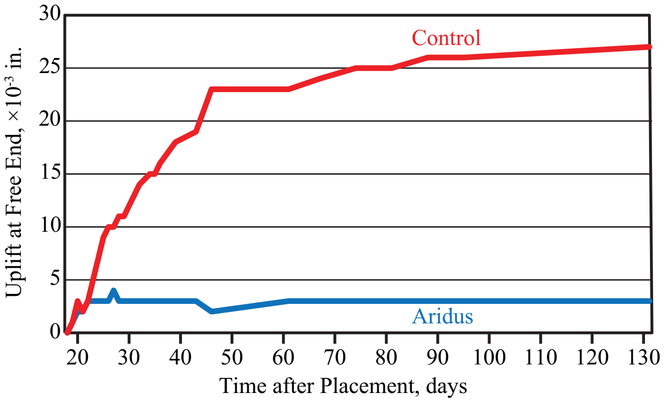


Fig. 4: Uplift versus time for curling test specimens fabricated using an Aridus mixture and a control mixture with *w/c* = 0.41. Although both mixtures show rapid initial uplift due to curl, the specimen comprising the Aridus mixture stabilized shortly after 20 days. At the conclusion of the test, the curling of the control specimen was nearly an order of magnitude greater than that of the Aridus specimen

control concrete mixture continued to increase for months (Fig. 4). The formulation has also been tested and was found to provide a good bond surface for all types of flooring adhesives (Fig. 5). Further evaluations are currently being conducted to incorporate ongoing improvements in the technology, with a focus on structural lightweight concrete.

Project experience

In addition to controlled studies, pilot field placements have been accomplished (Fig. 6). To date, these placements have totaled about 1000 yd^3 (765 m^3). Recently, Joseph J. Albanese, Inc., used the new concrete technology for the

Fig. 5: Bond peformance of various flooring materials and adhesives were used to verify that the new concrete mixture would perform as required

Fig. 6: Testing moved from the laboratory to the field to verify that the new concrete mixture could be placed and finished using modern equipment. Here, the mixture is being delivered using a concrete pump and being struck-off using a laser screed

slab-on-ground area of a high-tech manufacturing facility. The company successfully pumped the concrete at rates up to 85 yd^3/h (65 m^3/h); the mixture was internally vibrated, manually struck off, and finished using power trowels. Estimator Nick Dolci reported that the technology provided benefits that exceeded the small cost premium. Although the mixture was "a little stickier on the trowels," he reported that the placement went well.

THE COMPLETE SYSTEM

As with any concrete slab-on-ground that's to receive floor coverings, an effective below-slab vapor retarder must be installed directly below the slab. The Aridus fast-drying concrete formulation also requires that a low-permeance vapor retarder be installed directly in contact with the concrete. The below-slab vapor retarder should conform to the minimum requirements of ASTM E1745 Class A, with a water-vapor permeance reduced to not exceed 0.01 perm (0.6 $ng/[s \cdot m^2 \cdot Pa]$).

As with floors constructed using any other concrete mixture, curing compounds of any type should not be used when the floor is to subsequently receive a floor covering or coating. Curing should be accomplished by cover curing the finished slab for 72 hours.

Post-installation moisture testing of this new concrete solution is best accomplished through the measurement of the internal relative humidity of the slab in accordance with ASTM F2170. MVER testing by the calcium chloride method (ASTM F1869) can be performed along with RH testing if required by the specification.

References

1. Suprenant, B.A., and Malisch, W.R., "Quick-Dry Concrete: A New Market for Ready-Mix Producers," *The Concrete Producer*, May 1998, pp. 330-333.

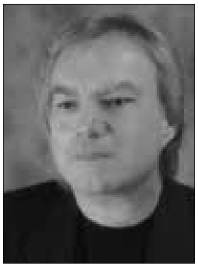
2. Suprenant, B.A., and Malisch, W.R., "Qualifying Quick-Dry Concrete," *The Concrete Producer*, Sept. 1998, pp. 619-620.

Note: Additional information on the ASTM Standards discussed in this article can be found at www.astm.org.

Selected for reader interest by the editors.

—U.S. Concrete, Inc.
www.us-concrete.com

ACI member **Randy Turpin** is Vice President of Technical Marketing for Houston, TX-based U.S. Concrete, Inc. He also directs the applied research laboratory for U.S.C. Technologies, a wholly-owed subsidiary of U.S. Concrete. In addition to the Aridus product, he has created several systems for concrete, including the use of foam in low density flowable fill.



ACI member **Peter Craig** is an independent Concrete Floor Consultant with more than 37 years of experience. He is a Past President of the International Concrete Repair Institute (ICRI) and serves as a Lead Instructor for the ICRI Moisture Testing Certification program. He is a member of ACI Committees 302, Construction of Concrete Floors, and 360, Design of Slabs on Ground. He has completed more than 300 moisture-related flooring investigations nationwide.